

TOSHIBA Bi-CMOS Linear Integrated Circuit Silicon Monolithic

# TB2936HQ

## 49 W × 4-ch BTL Audio Power IC

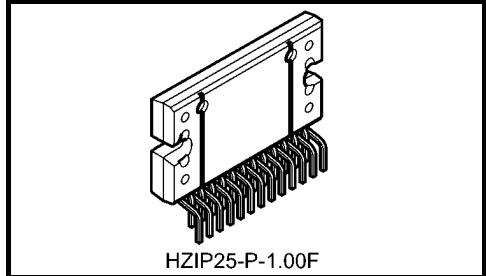
The TB2936HQ is a four-channel BTL power amplifier for car audio applications.

This IC has a pure complementary P-ch and N-ch DMOS output stage, offering maximum output power (POUT MAX) of 49 W.

It includes a standby switch, mute function and various protection features.

### Features

- High output power
  - POUT MAX (1) = 49 W (typ.)  
(VCC = 15.2 V, f = 1 kHz, JEITA max, RL = 4 Ω)
  - POUT MAX (2) = 43W (typ.)  
(VCC = 14.4 V, f = 1 kHz, JEITA max, RL = 4 Ω)
  - POUT (1) = 26 W (typ.)  
(VCC = 14.4 V, f = 1 kHz, THD = 10%, RL = 4 Ω)
  - POUT (2) = 23 W (typ.)  
(VCC = 13.2 V, f = 1 kHz, THD = 10%, RL = 4 Ω)
- Low THD: 0.015% (typ.) (VCC = 13.2 V, f = 1 kHz, POUT = 5 W, RL = 4 Ω)
- Low noise: VNO = 160 μVrms (typ.)  
(VCC = 13.2 V, Rg = 0 Ω, BW = 20 Hz to 20 kHz, RL = 4 Ω)
- Standby switch (pin 4)
- Mute function (pin 22)
- Output DC offset detection and clip detection (pin 25)
- Various protection features  
Thermal overload; overvoltage; output short-circuits to GND, VCC and across the load; speaker current limiting
- Operating supply voltage: VCC (opr) = 8.0 to 18 V (RL = 4 Ω)



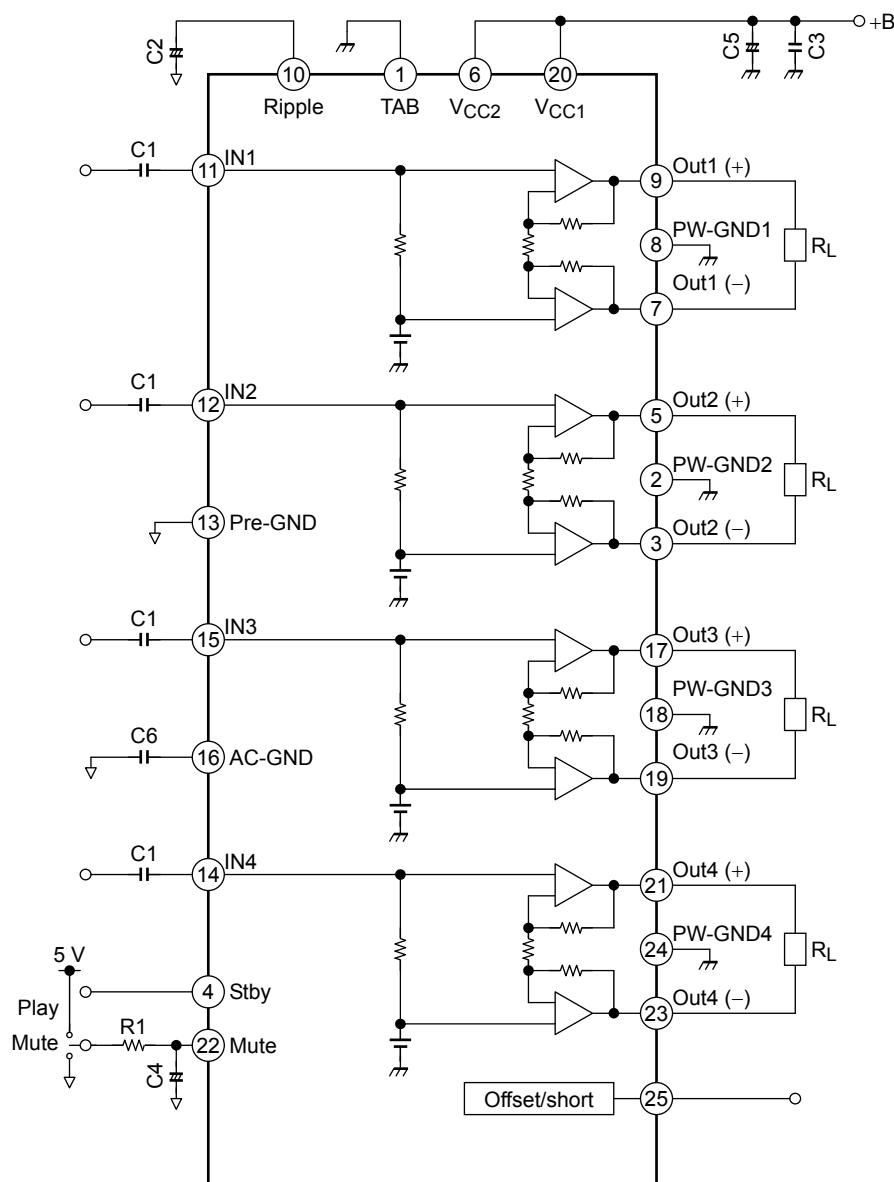
Weight: 7.7 g (typ.)

Note 1: Install the device correctly. Otherwise, the device or system may be degraded, damaged or even destroyed.

Note 2: The protection features are intended to avoid output short-circuits or other abnormal conditions temporarily. It is not guaranteed that they will prevent the IC from being damaged.

Exposure to conditions beyond the guaranteed operating ranges may not activate the protection features, resulting in an IC damage due to output short-circuits.

## Block Diagram



Some of the functional blocks, circuits or constants may be omitted from the block diagram or simplified for explanatory purposes.

## Detailed Description

(The following only describes one of the four channels, since all these channels are symmetrical.)

### 1. Standby Switch (pin 4)

The power supply can be turned on or off via pin 4 (Stby). The threshold voltage of pin 4 is set at about 3 VBE (typ.). The power supply current is about 0.01  $\mu$ A (typ.) in the standby state.

#### Standby Control Voltage (V<sub>SB</sub>): Pin 4

Standby	Power	V <sub>SB</sub> (V)
ON	OFF	0 to 0.9
OFF	ON	2.9 to VCC

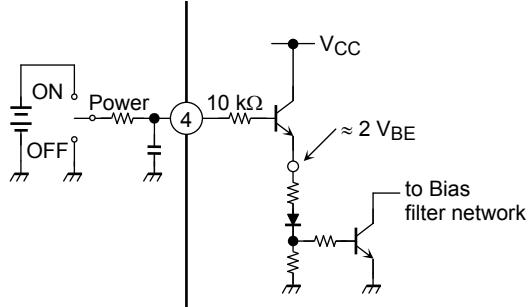


Figure 1 Setting Pin 4 High Turns on Power

Check the pop levels when the time constant of pin 4 is changed.

#### Benefits of the Standby Switch

- (1) VCC can be directly turned on or off by a microcontroller, eliminating the need for a switching relay.
- (2) Since the control current is minuscule, a low-current-rated switching relay can be used.

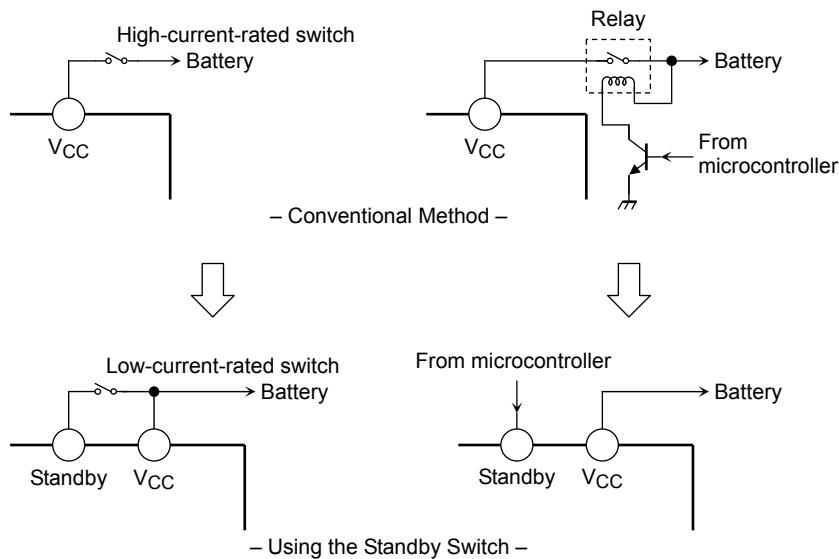


Figure 2 Standby Switch

## 2. Mute Function (pin 22)

The audio mute function is enabled by setting pin 22 Low. R<sub>1</sub> and C<sub>4</sub> determine the time constant of the mute function. The time constant affects pop noise generated when power or the mute function is turned on or off; thus, it must be determined on a per-application basis. (Refer to Figures 3 and 4.) The value of the external pull-up resistor is determined, based on pop noise value.

For example, when the control voltage is changed from 5 V to 3.3 V, the pull-up resistor should be:

$$3.3 \text{ V} / 5 \text{ V} \times 47 \text{ k}\Omega = 31 \text{ k}\Omega$$

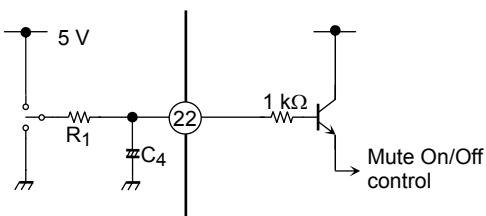


Figure 3 Mute Function

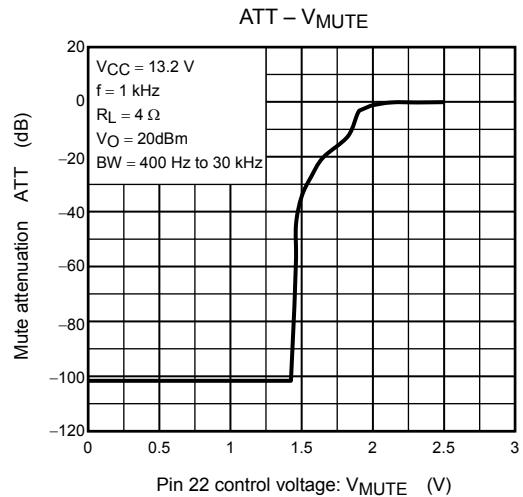
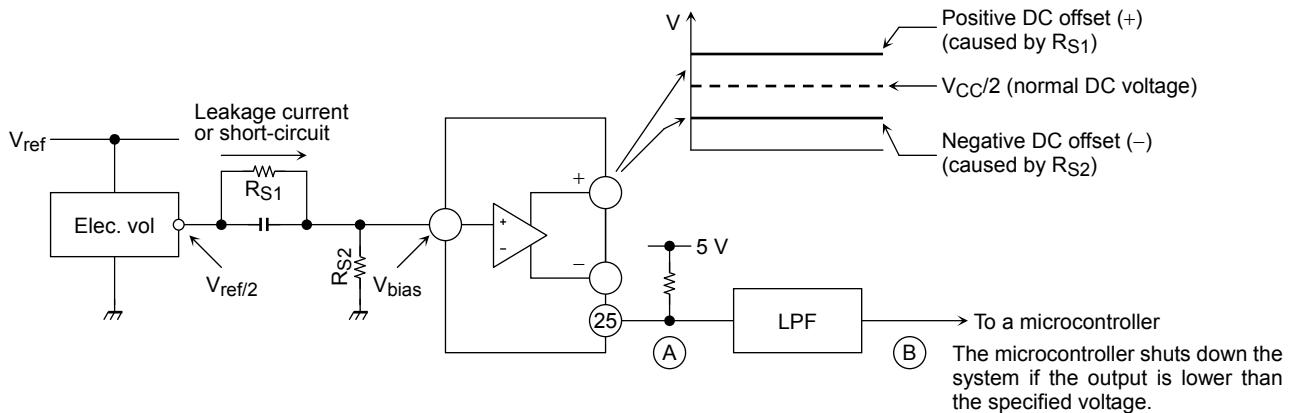


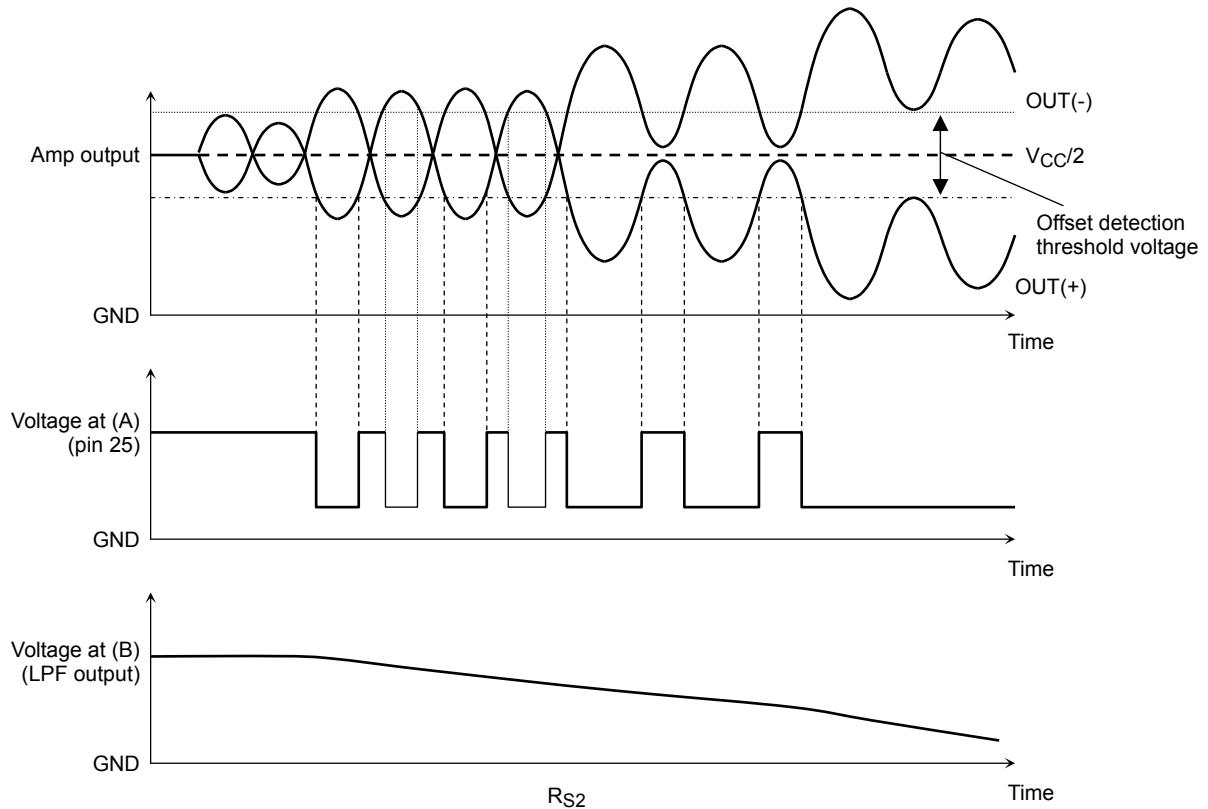
Figure 4 Mute Attenuation – V<sub>MUTE</sub> (V)

### 3. DC Offset Detection

The purpose of the integrated DC offset detector is to avoid an anomalous DC offset on the outputs, produced by the input capacitor due to leakage current or short-circuit.



**Figure 5 DC Offset Detection Mechanism**



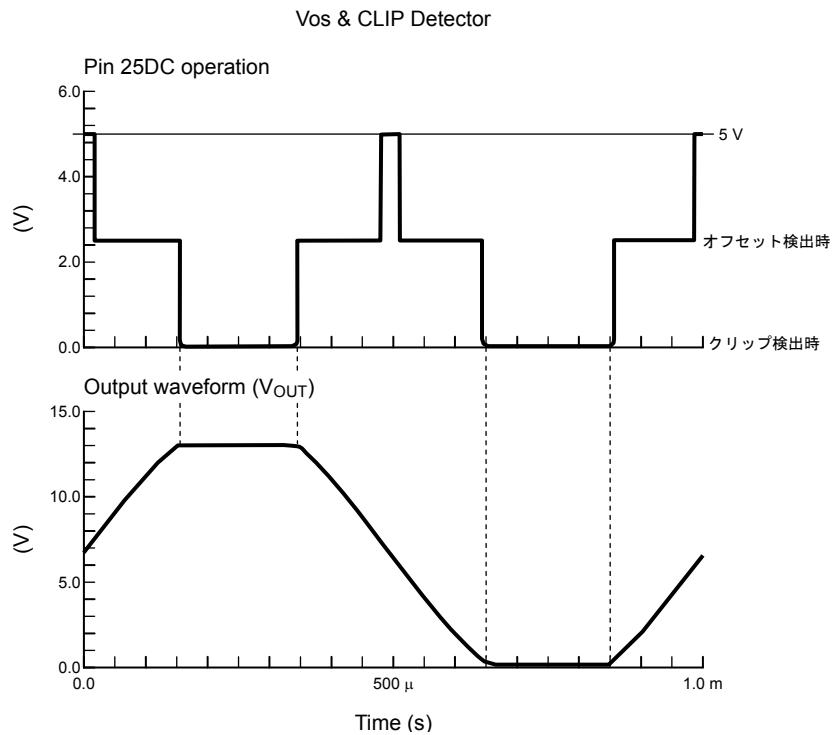
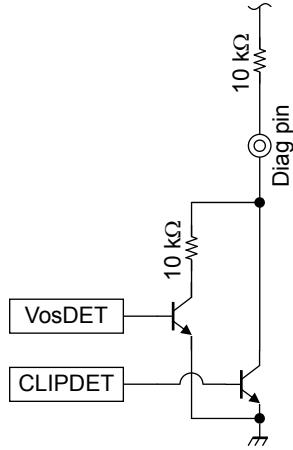
#### 4. Clip Detection

Pin 25 is an open-collector output (active-low) as shown in Figure 6.

When the output voltage waveform is clipped, the internal clip detector is activated so that the NPN transistor Q1 is enabled.

The sound quality can be improved by controlling the volume and tone control circuitry using this output signal.

Pin 25 should be left open when this feature is not required.



**Figure 6** Open-Collector Output of Pin 25

**Figure 7** Waveform of Pin 25 upon Offset and Clip Detections

## 5. Prevention of speaker damage (in case of a layer short-circuit of the speaker)

When the DC resistance between the OUT+ and OUT- pins falls below 1 Ω, the output current exceeds 4 A. At this time, the protection circuit is activated to limit the current draw into the speaker. This feature prevents the speaker from being damaged, as follows:

### < Speaker damaging scenario >

A DC current of over 4 V is applied to the speaker due to an external circuit failure (Note 4).

(Abnormal DC output offset)



The speaker impedance becomes 1 Ω or less due to a layer short.



A current of over 4 A flows into the speaker, damaging the speaker.

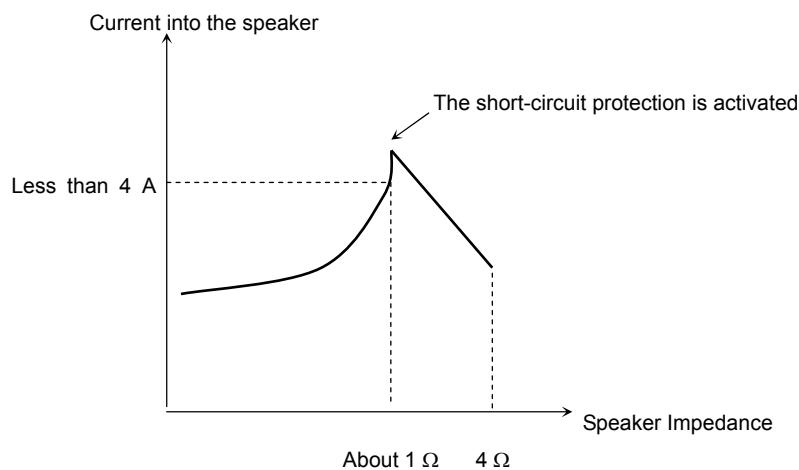


Figure 8

Note 4: An abnormal DC offset voltage is incurred when the input bias to the power IC is lost due to a leakage current from a coupling capacitor at the input or a short-circuit between the IN and adjacent lines.

## 6. Pop Noise Suppression

Since the TB2936HQ uses the AC-GND pin (pin 16) as the common input reference voltage pin for all amplifiers, the ratio of the input capacitance (C1) to the AC-to-GND capacitance (C6) should be 1:4.

Also, if power is removed before C1 and C6 are completely charged, pop noise will be generated because of unbalanced DC currents.

To avoid this problem, it is recommended to use a larger capacitor as C2 to increase the charging times of C1 and C6. Note, however, that C2 also affects the time required from power-on to audio output.

The pop noise generated by the muting and unmuting of the audio output varies with the time constant of C4. A larger capacitance reduces the pop noise, but increases the time from when the mute control signal is applied to C4 to when the mute function is enabled.

## 7. External Component Constants

Component	Recommended Value	Purpose	Effects		Notes
			When lower than recommended value	When higher than recommended value	
C1	0.22 $\mu$ F	To eliminate DC	Cut-off frequency is increased.	Cut-off frequency is reduced.	Pop noise is generated when V <sub>CC</sub> is turned on.
C2	10 $\mu$ F	To reduce ripple	Powering on/off is faster.	Powering on/off is slower.	
C3	0.1 $\mu$ F	To provide sufficient oscillation margin	Reduces noise and provides sufficient oscillation margin		
C4	1 $\mu$ F	To reduce pop noise	High pop noise. Duration until mute function is turned on/off is short.	Low pop noise. Duration until mute function is turned on/off is long.	
C5	3900 $\mu$ F	Ripple filter	Power supply humming and ripple filtering.		
C6	1 $\mu$ F	Common reference voltage for all input	Pop noise is suppressed when C1: C6 = 1:4.		Pop noise is generated when V <sub>CC</sub> is turned on.

## Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Peak supply voltage (0.2 s)	V <sub>CC</sub> (surge)	50	V
DC supply voltage	V <sub>CC</sub> (DC)	25	V
Operating supply voltage	V <sub>CC</sub> (opr)	18	V
Output current (peak)	I <sub>O</sub> (peak)	9	A
Power dissipation	P <sub>D</sub> (Note 5)	125	W
Operating temperature	T <sub>opr</sub>	-40 to 85	°C
Storage temperature	T <sub>stg</sub>	-55 to 150	°C

Note 5: Package thermal resistance  $\theta_{j-T} = 1^{\circ}\text{C}/\text{W}$  (typ.) (Ta = 25°C, with infinite heat sink)

The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.

If any of these ratings are exceeded during operation, the electrical characteristics of the device may be irreparably altered and the reliability and lifetime of the device can no longer be guaranteed.

Moreover, any exceeding of the ratings during operation may cause breakdown, damage and/or degradation in other equipment. Applications using the device should be designed so that no absolute maximum rating will ever be exceeded under any operating conditions.

Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

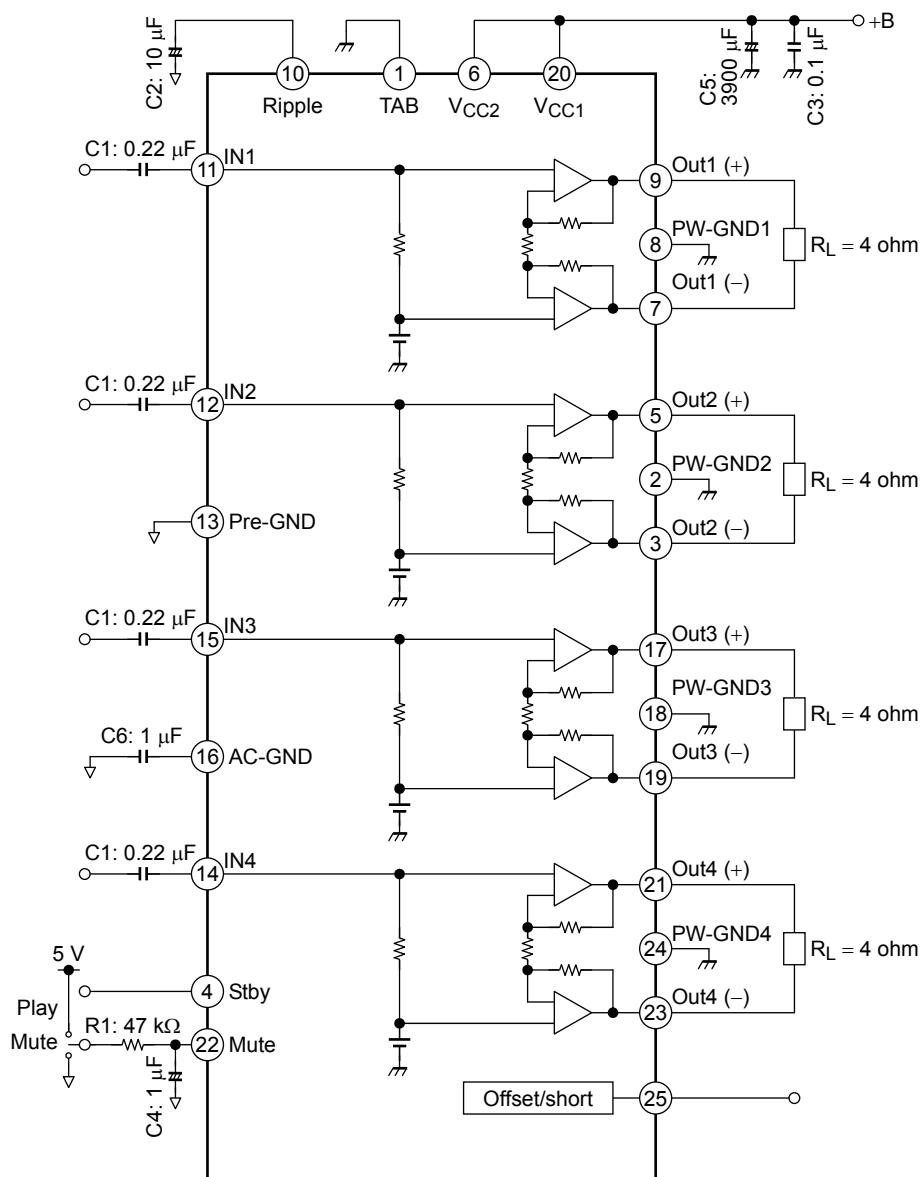
## Electrical Characteristics

(V<sub>CC</sub> = 13.2 V, f = 1 kHz, R<sub>L</sub> = 4 Ω, Ta = 25°C unless otherwise specified)

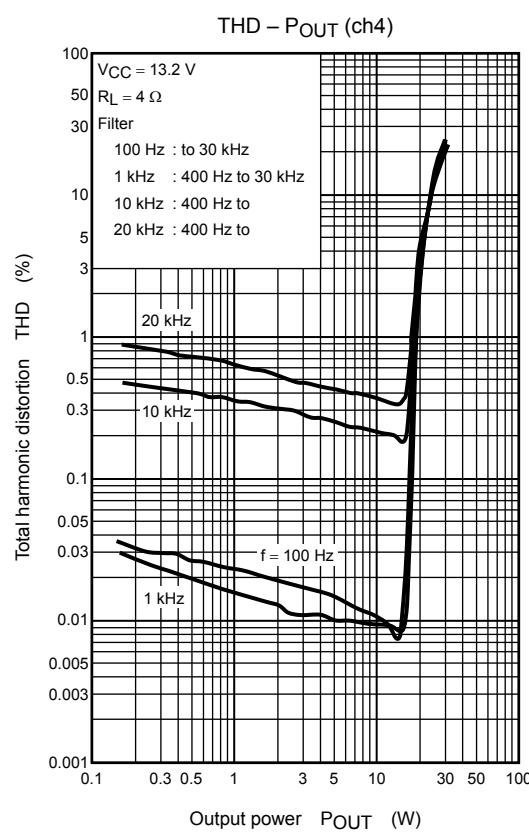
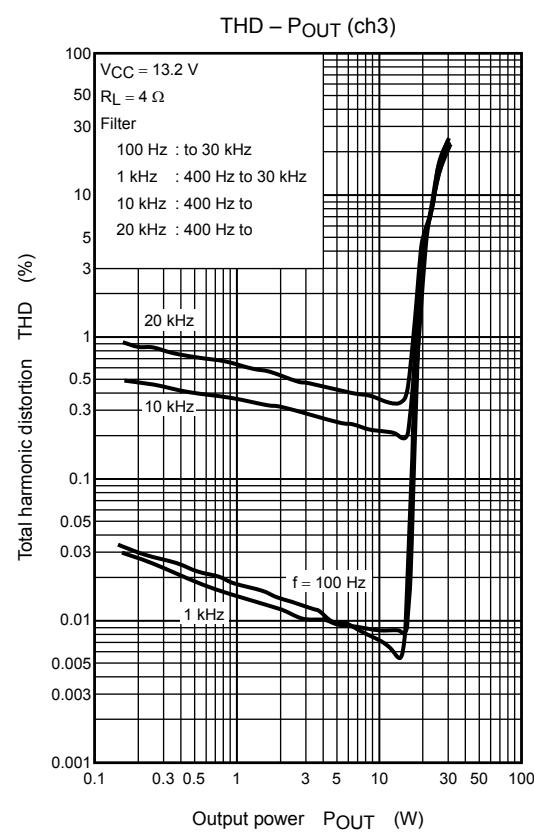
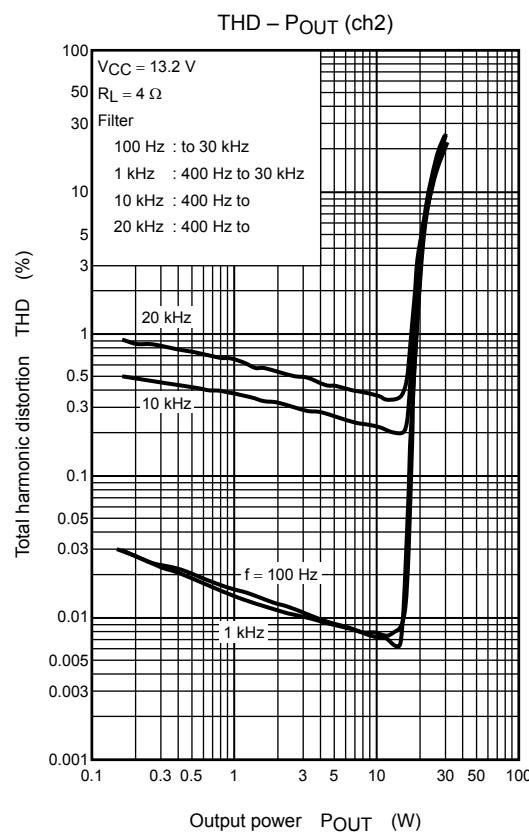
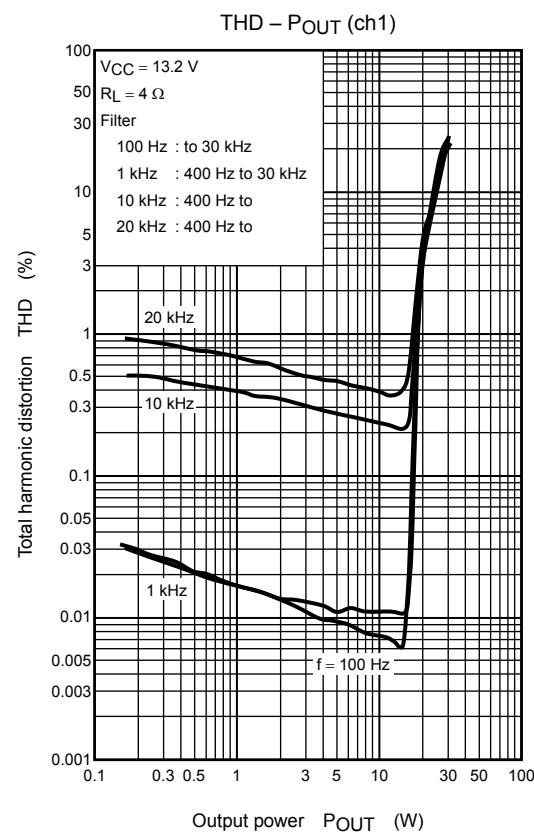
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Quiescent supply current	I <sub>CCQ</sub>	—	V <sub>IN</sub> = 0	—	160	320	mA
Output power	POUT MAX (1)	—	V <sub>CC</sub> = 15.2 V, max POWER	—	49	—	W
	POUT MAX (2)	—	V <sub>CC</sub> = 14.4 V, max POWER	—	43	—	
	POUT MAX (3)	—	V <sub>CC</sub> = 13.7 V, max POWER	—	39	—	
	POUT (1)	—	V <sub>CC</sub> = 14.4 V, THD = 10%	—	26	—	
	POUT (2)	—	THD = 10%	21	23	—	
Total harmonic distortion	THD	—	POUT = 5 W	—	0.015	0.08	%
Voltage gain	G <sub>V</sub>	—	V <sub>OUT</sub> = 0.775 Vrms	33	34	35	dB
Channel-to-channel voltage gain	ΔG <sub>V</sub>	—	V <sub>OUT</sub> = 0.775 Vrms	-1.0	0	1.0	dB
Output noise voltage	V <sub>NO</sub> (1)	—	R <sub>g</sub> = 0 Ω, DIN45405	—	160	—	μVrms
	V <sub>NO</sub> (2)	—	R <sub>g</sub> = 0 Ω, BW = 20 Hz to 20 kHz	—	160	250	
Ripple rejection ratio	R.R.	—	f <sub>rip</sub> = 100 Hz, R <sub>g</sub> = 620 Ω, V <sub>rip</sub> = 0.775 Vrms	45	52	—	dB
Crosstalk	C.T.	—	R <sub>g</sub> = 620 Ω, POUT = 4W	—	67	—	dB
Output offset voltage	V <sub>OFFSET</sub>	—	—	-185	0	185	mV
Output offset voltage while the mute function is turned on/off	ΔV <sub>OS</sub>	—	—	-85	0	85	mV
Input resistance	R <sub>IN</sub>	—	—	—	30	—	kΩ
Standby current	I <sub>SB</sub>	—	Standby condition, V <sub>4</sub> = 0, V <sub>22</sub> = 0	—	0.01	1	μA
Standby control voltage	V <sub>SB</sub> H	—	POWER: ON	2.9	—	V <sub>CC</sub>	V
	V <sub>SB</sub> L	—	POWER: OFF	0	—	0.9	

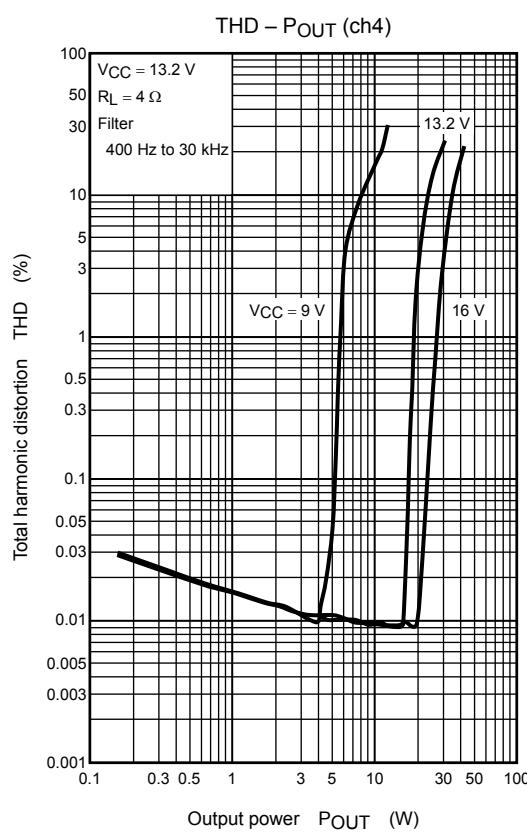
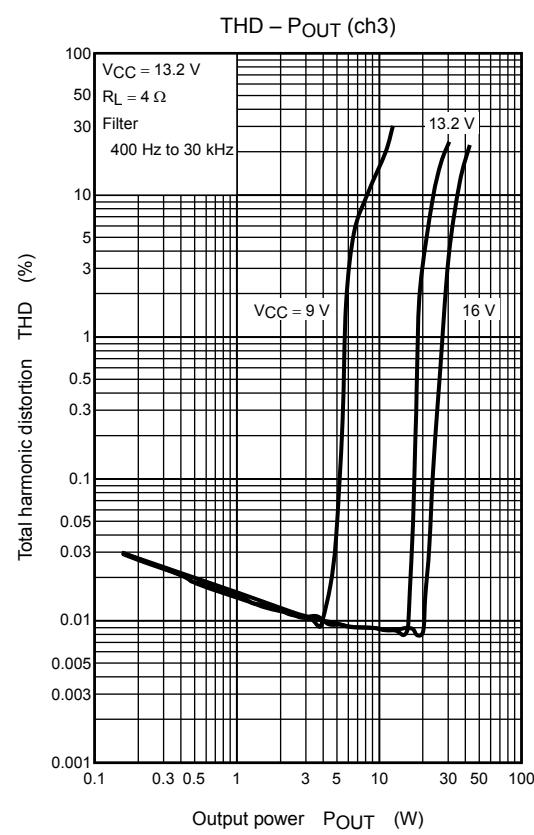
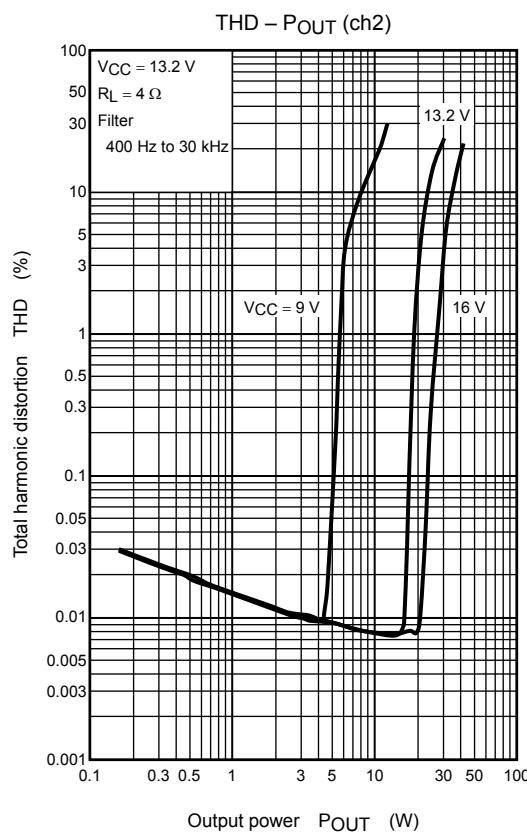
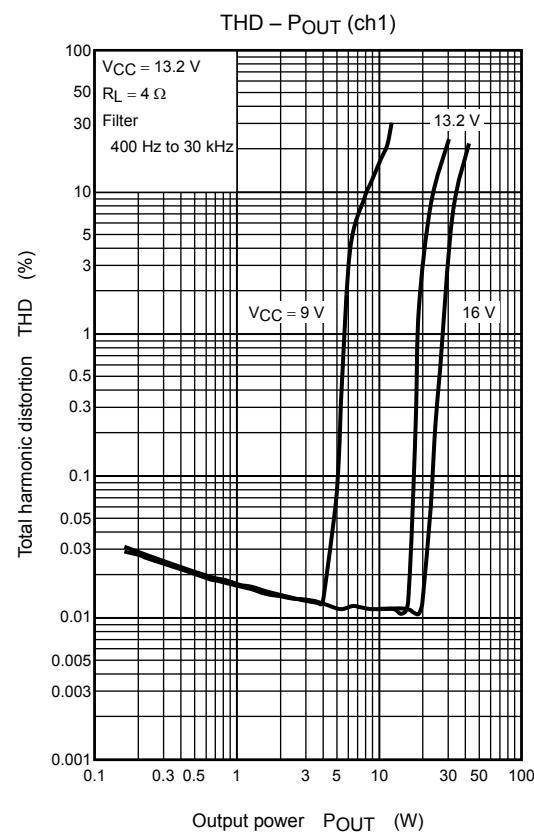
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Mute control voltage	V <sub>M</sub> H	—	MUTE: OFF	2.9	—	V <sub>CC</sub>	V
	V <sub>M</sub> L	—	MUTE: ON, R <sub>1</sub> = 47 kΩ	0	—	0.9	
Mute attenuation	ATT M	—	MUTE: ON, DIN_AUDIO V <sub>OUT</sub> = 7.75 Vrms → Mute: OFF	85	100	—	dB
Clip detection threshold	CLD-DET	—	when pin 25 = low	—	1	5	%
Upper cut-off frequency	F <sub>th</sub>	—	G <sub>V</sub> = 26dB, 3dB	—	250	—	kHz
DC offset threshold voltage	V <sub>off-set</sub>	—	R <sub>pull-up</sub> = 10 kΩ, +V = 5.0 V Out (+)-Out (-)	±1.0	±1.5	±2.0	V
Pin 25 saturation voltage (at each detector ON condition)	P25-Sat	—	R <sub>pull-up</sub> = 10 kΩ, +V = 5.0 V (pin 25 = low)	—	100	500	mV

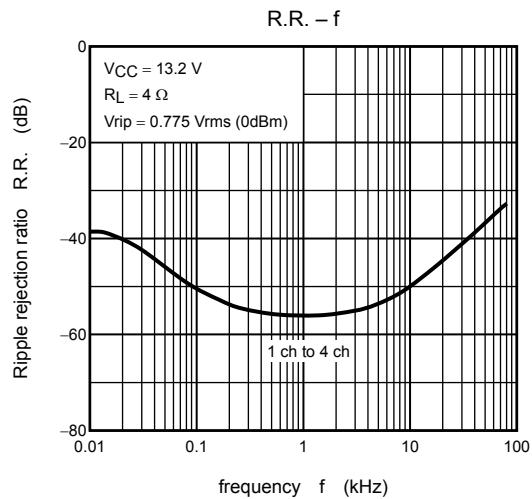
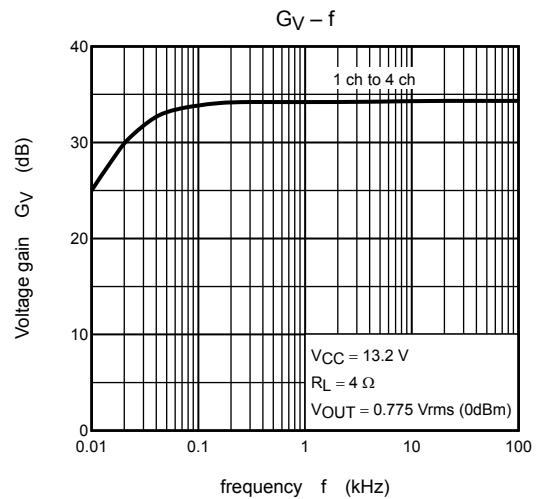
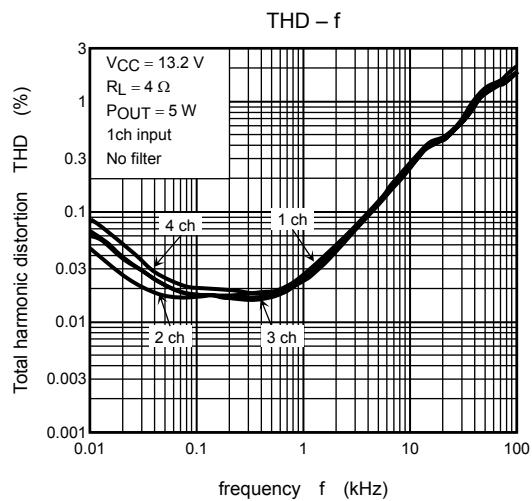
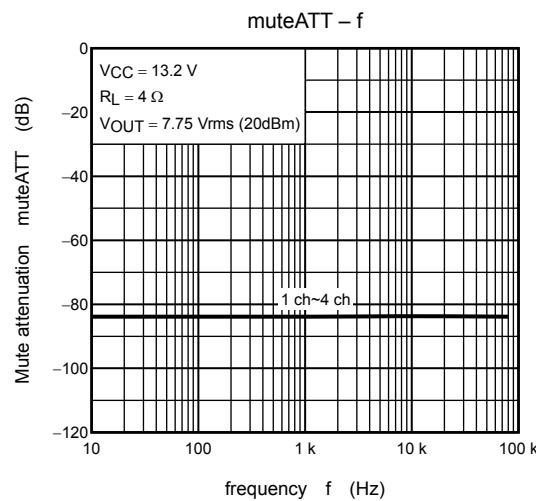
## Test Circuit

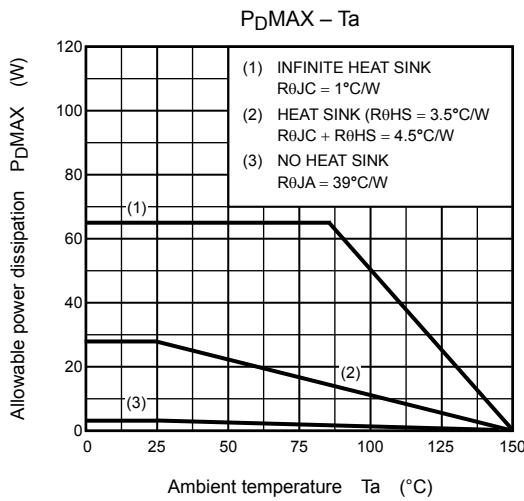
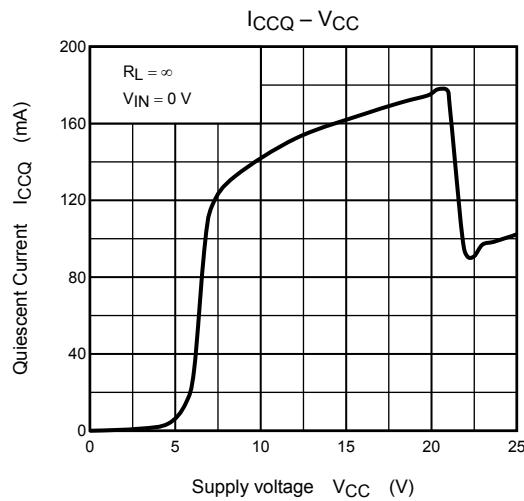
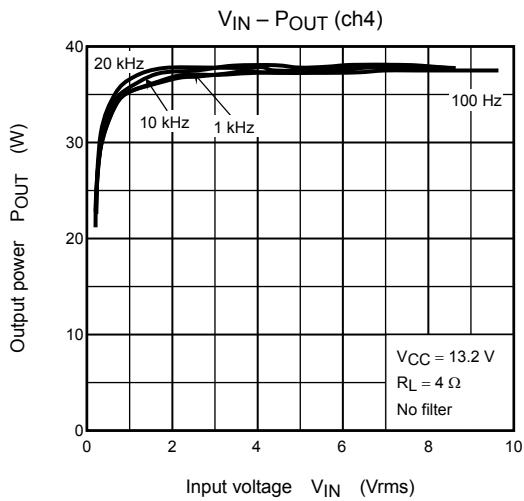
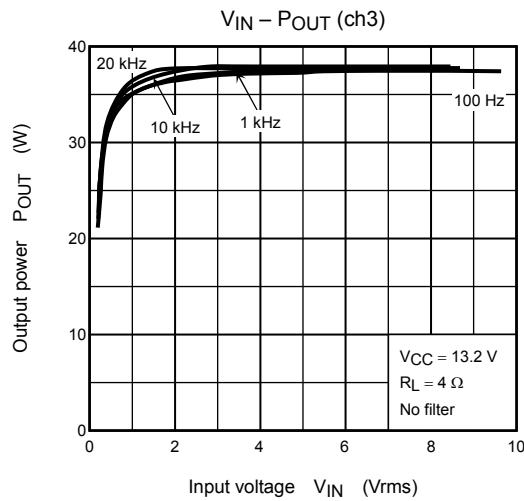
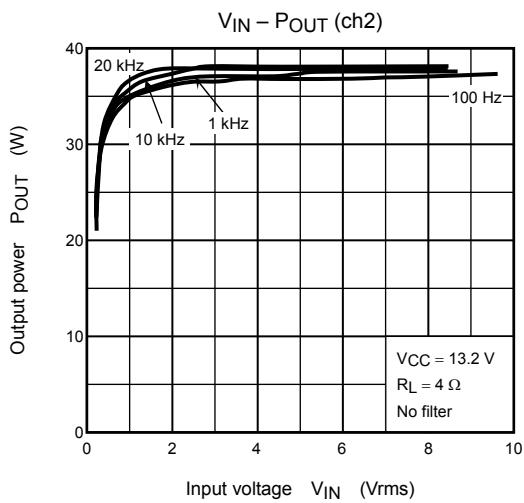
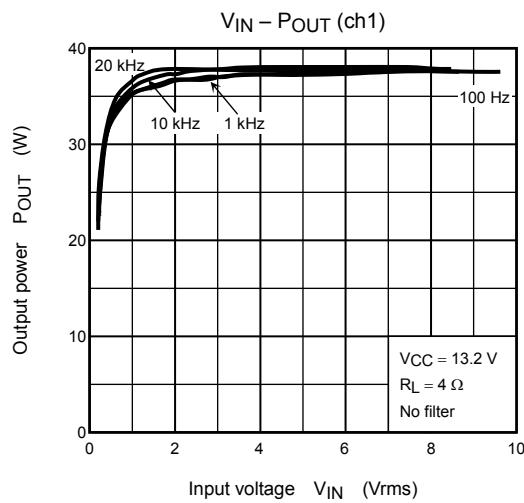


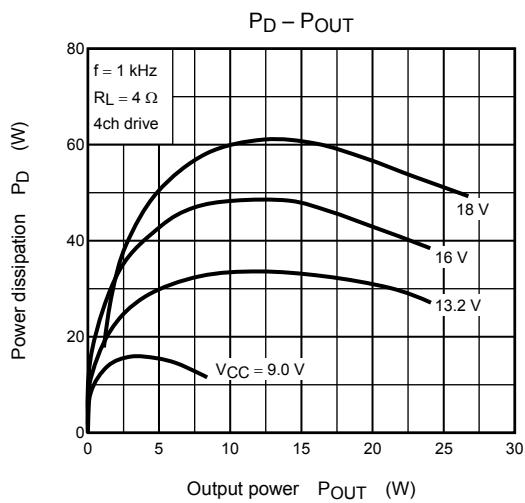
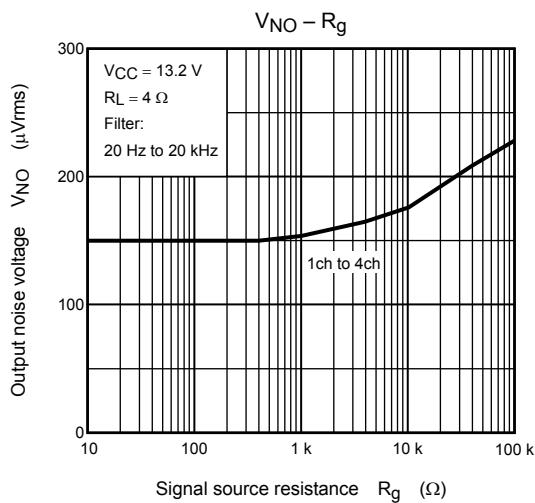
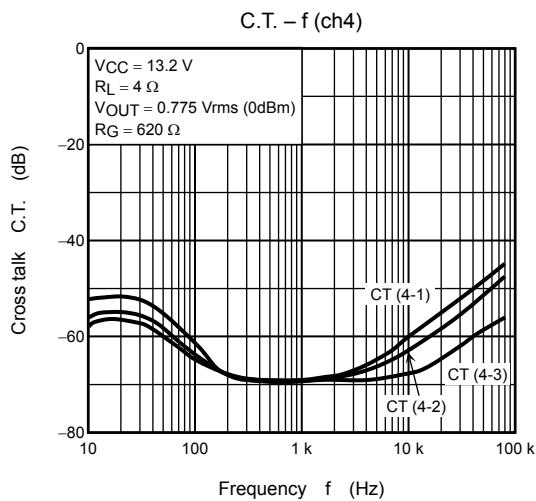
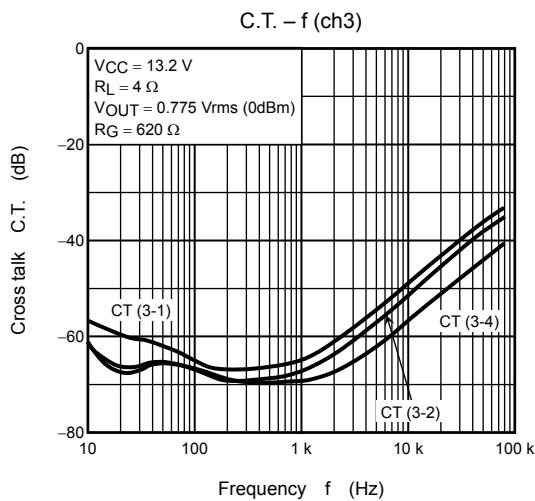
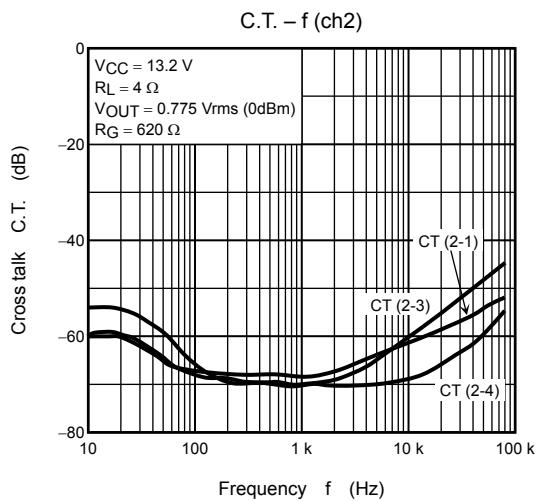
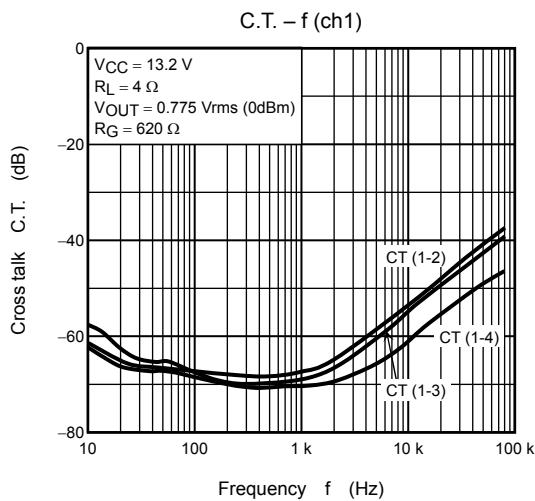
Components in the test circuit are only used to determine the device characteristics.  
It is not guaranteed that the system will work properly with these components.



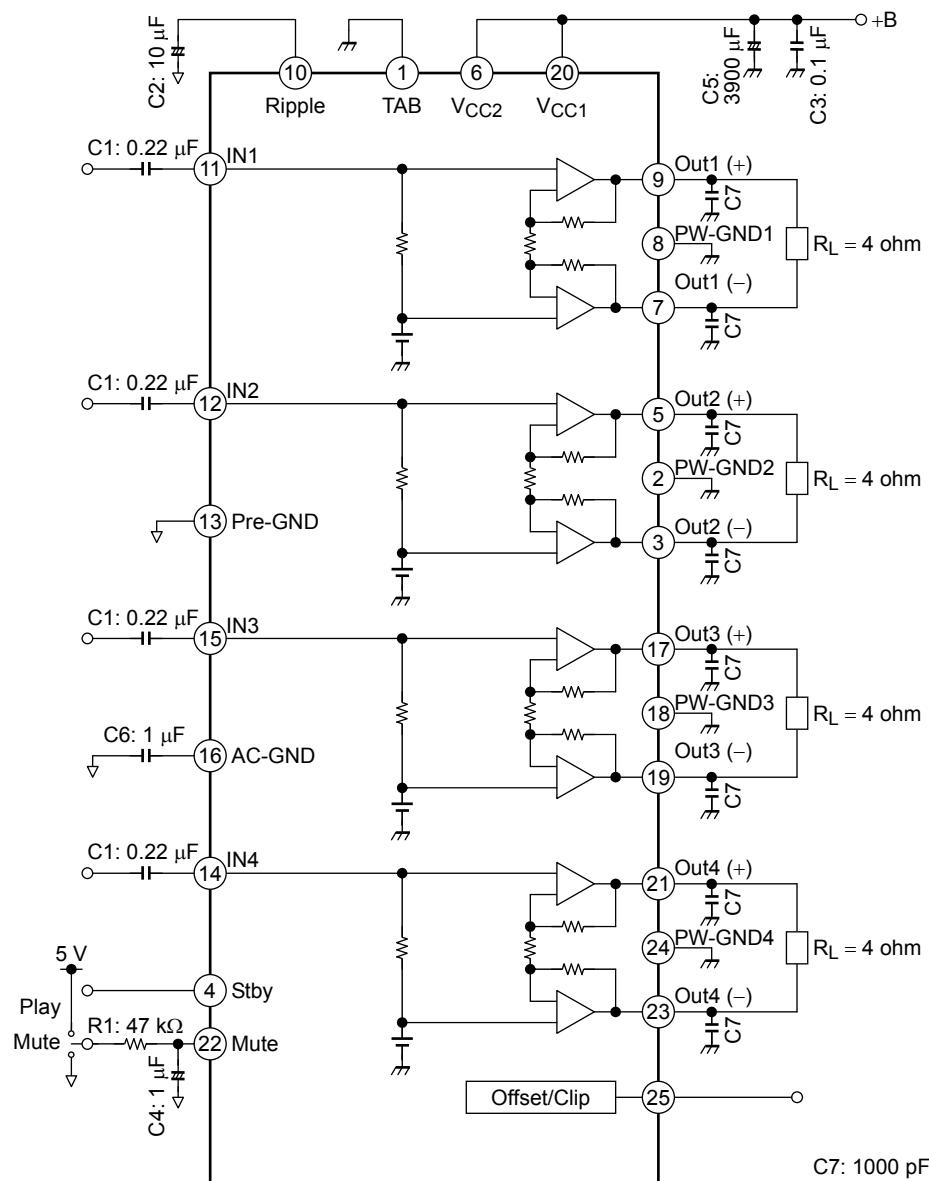








## Application Circuit (EMC-compliant)

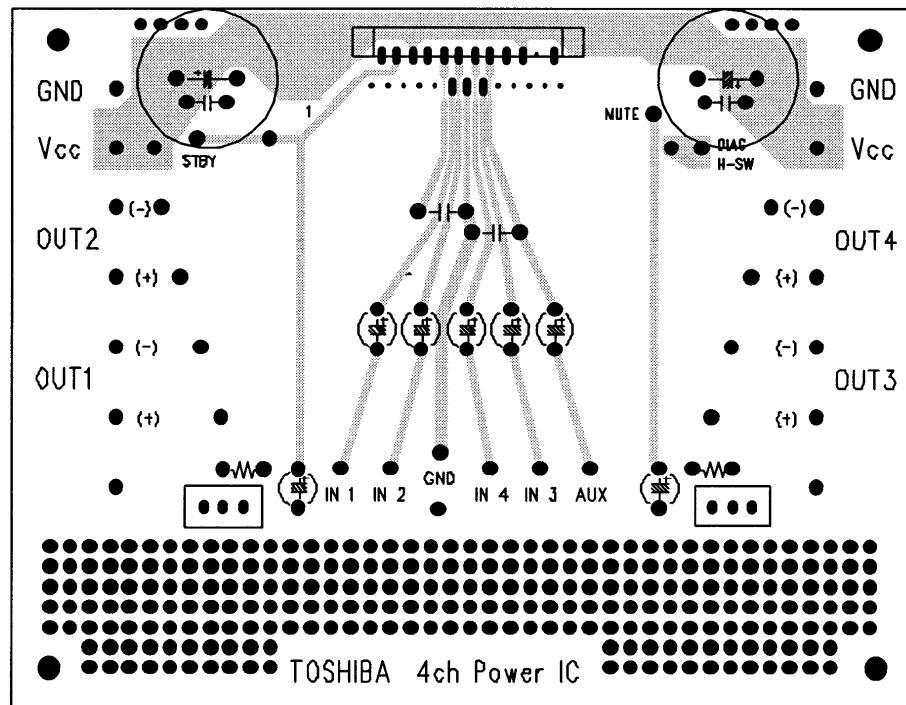
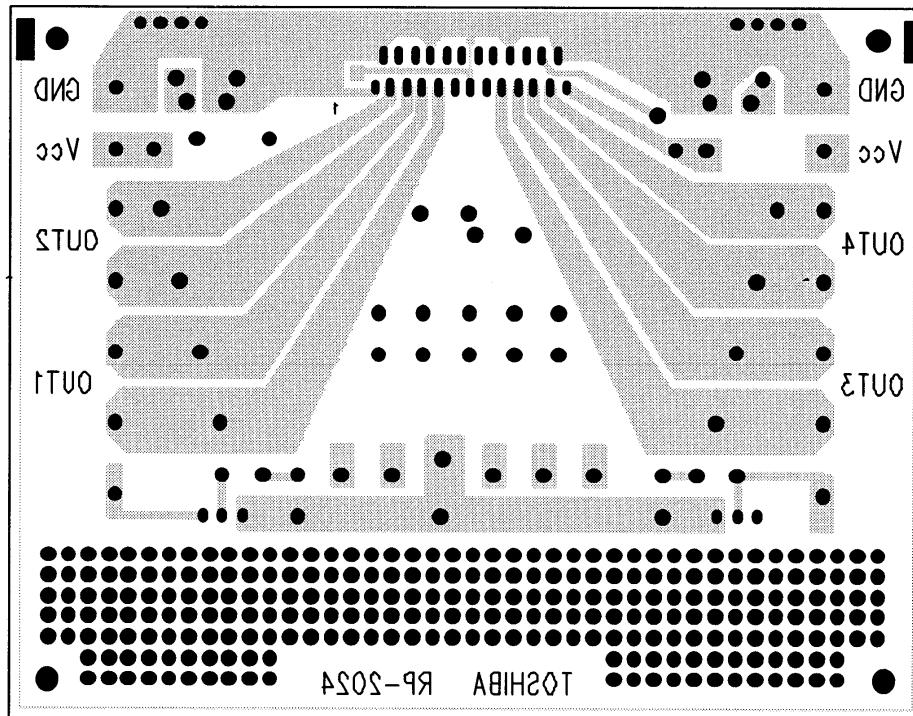


The devices used in the test circuit are intended to be used only for verifying the characteristics of the device. It is not guaranteed that this application equipment works properly.

**Test Board Layout for TOSHIBA 4-Channel Power Circuitry**

The layout diagrams below illustrate the front and back sides of the test board "RP-2024" for testing Toshiba's 4-channel power circuitry, which is housed in a HZIP25-P-1.00F (SPP25) package.

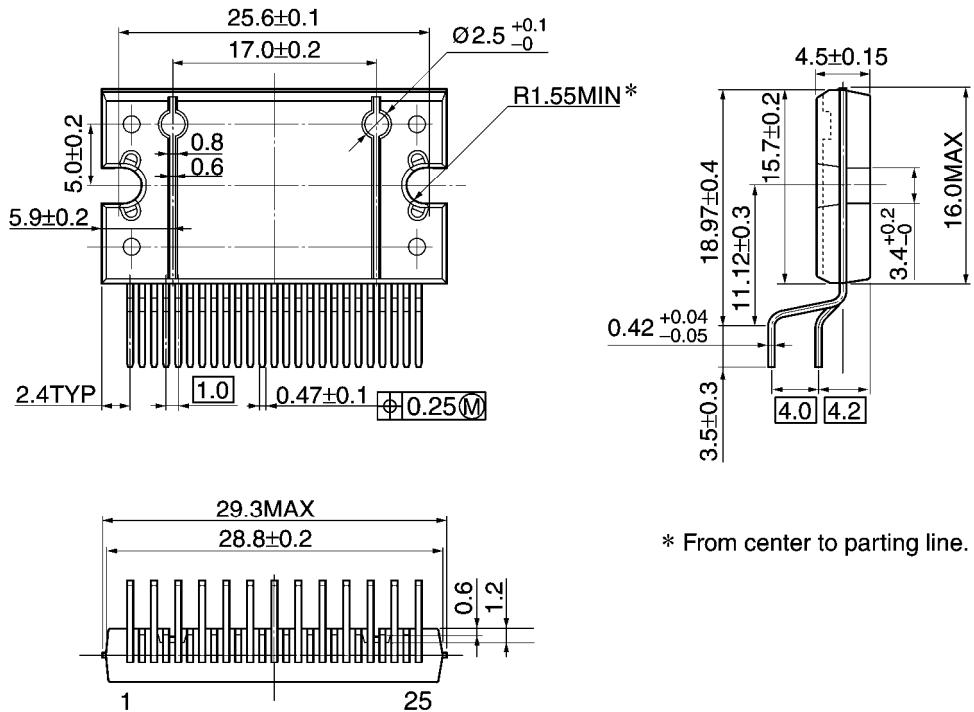
Note: This test board is designed to be used for several power amplifiers. Therefore, devices that are externally connected to the power amplifier to be tested must be checked before setting up the test board.

**Front Side****Back Side**

**Package Dimensions**

HZIP25-P-1.00F

Unit: mm



Weight: 7.7 g (typ.)

- Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. For details on how to connect a protection circuit such as a current limiting resistor or back electromotive force adsorption diode, refer to individual IC datasheets or the IC databook. IC breakdown may cause injury, smoke or ignition.
- Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator. If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure can cause smoke or ignition. (The over current can cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection type IC that inputs output DC voltage to a speaker directly.

- Over current Protection Circuit

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

- Thermal Shutdown Circuit

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the Thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

- Heat Radiation Design

When using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature ( $T_j$ ) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

- Installation to Heat Sink

Please install the power IC to the heat sink not to apply excessive mechanical stress to the IC. Excessive mechanical stress can lead to package cracks, resulting in a reduction in reliability or breakdown of internal IC chip. In addition, depending on the IC, the use of silicon rubber may be prohibited. Check whether the use of silicon rubber is prohibited for the IC you intend to use, or not. For details of power IC heat radiation design and heat sink installation, refer to individual technical datasheets or IC databooks.

About solderability, following conditions were confirmed

- Solderability

- (1) Use of Sn-37Pb solder Bath

- solder bath temperature = 230°C
    - dipping time = 5 seconds
    - the number of times = once
    - use of R-type flux

- (2) Use of Sn-3.0Ag-0.5Cu solder Bath

- solder bath temperature = 245°C
    - dipping time = 5 seconds
    - the number of times = once
    - use of R-type flux

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